United States
Department of
Agriculture

Agricultural
Research Service

Agricultural Research Service Technology Transfer Plan

EXECUTIVE SUMMARY

Since 1953--when the Agricultural Research Service (ARS), U.S. Department of Agriculture (USDA), was established as the Department's chief research organization--the prompt transfer of the Agency's technology (scientific findings) to the public has been a major activity. Key users of ARS findings include farmers and ranchers, agriculture-related industries, the Cooperative Extension Service, the Soil Conservation Service and other action agencies, State and local governments, and consumers and consumer groups. The ARS has--in its research and technology transfer activities--recognized the need for findings that can solve problems and be integrated into the management systems of farmers, industries, and other users. Moreover, transfer activities provide a route for feedback from users to ARS. Such feedback indicates not only whether the integration of ARS technology into users' operations has increased efficiency but also identifies users' needs for additional or new technology.

The first policy for implementation of the ARS Program Plan is--"the Administrator will operate ARS as a managed activity coordinated by plan." ARS is following that policy by organizing its activities for the dissemination of research findings into the Technology Transfer Plan.

The objectives of the ARS Technology Transfer Plan are to--

1. Inform users and potential users of ARS capabilities, research programs, and cooperative stance;
2. Collect from users any feedback on their experiences with adopted ARS technology that could improve the planning and evaluation of research;
3. Interest and assist users and potential users in developing new technology from ARS findings and in modifying their operations for its adoption; and
4. Encourage and assist users in exploiting directly applicable ARS research findings.

Mechanisms for achieving the objectives of the ARS Technology Transfer Plan are--

1. Direct communications between scientists and users;
2. Involvement of users and potential users in research planning and evaluation;
3. Joint research with users and potential users;

4. Transfer of ARS research findings to the Cooperative Extension Services by computer;

5. Research reporting by ARS Information Staff;

6. Patent activities;

7. Participation in the Federal Laboratory Consortium; and

8. System for electronically collecting, storing, and retrieving the latest research findings for technology transfer.

In 1983, approximately 85 staff-years of effort by ARS scientists went toward the technology transfer objectives. ARS scientists spent between 3 and 4 percent of their time making more than 61,000 contacts with all key user groups. Contacts by scientists included--in order of declining importance--individuals; joint research arrangements; formal meetings with groups; technical adviser to groups; demonstrations, field days, etc.; articles in trade press; and public media.

Additionally, in 1983, other ARS groups--which contributed 80 staff-years to technology transfer--included the ARS Information Staff, specialists engaged in patent-related activities, and the National Program Staff. During the last 5 years, 215 patents resulted from ARS research. ARS maintains close liaison with the National Technical Information Service to move ARS patents into commercialization.

A few examples of ARS technology successfully transferred to key users in recent years include:

- Alternatives to Mirex for fire ant control benefiting farmers and the general public.
- Elimination of toxicity problems with tall fescue that will save cattlemen $200 million.
- An automated system for handling live poultry that saves the industry $12-$14 million per year.
- Durable flame-retardant treatment for 100-percent cotton fabric. In 1982 more than 8 million yards of fabric were treated. Uses include uniforms for astronauts.
- Erosion-Productivity Impact Calculator. Provides invaluable information on soil erosion that is being used by Soil Conservation Service, Economic Research Service, other

researchers, and Extension to develop programs for conserving soil productivity.

- Export technologies for U.S. commodities in European markets. With the assistance of the Foreign Agricultural Service, a multimillion dollar market was developed for U.S. watermelons, lettuce, Texas grapefruit, and kiwi fruit.

In ARS, technology transfer is an integral factor in all phases of research planning. The function of technology transfer--the dissemination of research findings to the public--is the culmination of all ARS activities. To enhance that function and carry it out most efficiently and effectively, ARS is organizing all its related activities--present and proposed--into the Technology Transfer Plan. The activities will be more formally structured, coordinated, and tracked. Research managers will encourage, support, and reward the efforts and will include tactics and allocations for them in annual research and management plans. Use of modern electronic communication and automation systems will be increased. Technology transfer will be represented by a coordinator on the National Program Staff and will be monitored and assisted by the ARS Office of Research and Technology Applications.

CONTENTS

Page

Executive Summary. i

Introduction 1

Policy and Objectives for ARS Technology Transfer. 2

ARS Technology Transfer Mechanisms 3

Integration of Technology Transfer and Research 7

Level of Current ARS Technology Transfer Efforts 8

Examples of Technology Transfer by Research Program Plan Objectives. 9

ARS Technology Transfer Coordination and Tracking 10

Conclusion 11

Issued May 1984

Agricultural Research Service Technology Transfer Plan

INTRODUCTION

The Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA) is a mission-oriented agency. To carry out its mission with renewed vigor, enhanced efficiency, and modern flexibility, 500 ARS scientists and the members of the ARS National Program Staff developed--through strategic planning--the ARS Program Plan, with six objectives (U.S. Department of Agriculture, Miscellaneous Publication No. 1429, 1983). For following the Program Plan from year to year, they developed the 6-Year Implementation Plan (1984-90) that is updated annually. The beneficiaries of the ARS mission, plans, and research are agriculture--the Nation's largest industry--the fifth of U.S. citizens whose jobs depend upon agriculture and related industries, and all people, here and abroad, who need U.S. feed, food, fiber, and processed agricultural products. To ensure that the benefits of ARS research are most effectively distributed and that the returns on the public funds invested in ARS are fully realized, ARS administrators and the National Program Staff have developed the ARS Technology Transfer Plan.

The Technology Transfer Plan is designed primarily to transmit to users and potential users the technology (scientific findings) that ARS scientists develop for solving agricultural problems. The Plan is not mainly concerned with the exchange of information among scientists; they communicate freely with their peers worldwide by publishing their findings in specialized technical journals and presenting them at meetings of technical societies.

The users of ARS problem-solving technology include farmers and ranchers, manufacturers and suppliers of farm inputs, industries that store, process, transport, and market agricultural commodities, and the ultimate users--consumers. Users also include national, State, and local regulatory agencies and governments. Everybody benefits when ARS technologies are successfully used to solve problems. Public funds invested in the research are returned, with interest, to the public as profits for farmers and all people associated with farming and as savings to consumers of the U.S. farm products worldwide.

Since the establishment of ARS in 1953, delivery of its research findings to the public has been a major activity. The mechanisms described in the ARS Technology Transfer Plan will ensure that the transmittal of knowledge and problem-solving research findings to users is efficient and effective. The mechanisms will also enable ARS to track its findings to their applications, evaluate their effectiveness, identify other problems that must be solved, and set priorities among them.

POLICY AND OBJECTIVES FOR ARS TECHNOLOGY TRANSFER

Policy

The first policy for implementation of the ARS Program Plan is--"the Administrator will operate ARS as a managed activity coordinated by plan." In line with that policy, the Technology Transfer Plan defines specific activities for delivering to users ARS findings for solving the technical problems of farmers and their related industries. The Plan also defines activities for tracking the transfer of technology, monitoring the efficiency of transfer, evaluating the effectiveness of ARS technology, and identifying problems that remain and new problems as they arise. Findings from that combination of activities will guide ARS in setting priorities among the problems that have slowed the rate of increase in farmers' efficiency and sapped their profits.

Technology Transfer Objectives

ARS will carry out technology transfer activities to achieve the following specific objectives:

1. Inform users and potential users of ARS capabilities, research programs, and cooperative stance. Good rapport between the people with the problems and the research agency able to solve them is essential to effectively identify and solve problems in the food and agricultural system. Consequently, user groups must be fully and clearly informed of the kinds of scientists, facilities, and research ARS can bring to bear on their problems and the Agency's desire to cooperate with them in problem-solving.

2. Collect from users any feedback, on their experiences with adopted ARS technology, that could improve the planning and evaluation of research. Technology transfer activities work in two directions and produce benefits at both ends. Just as users need to be familiar with ARS' problem-solving capabilities, so the Agency needs all the information it can get from users and potential users to identify, assess, and assign priorities among the most critical problems. Information from users is also needed to design and monitor research projects aimed at solving specific problems. For collecting such information, appropriate user groups should be involved in ARS research planning at the national and laboratory levels.

3. Interest and assist users and potential users in developing new technology from ARS research findings and in modifying their operations for its adoption. This objective pertains to research results that provide new scientific frameworks for innovative solutions to problems. Often some

intermediary, such as large or small agribusinesses, manufacturers, and suppliers, must become involved before the benefits can be realized by farmers and consumers. Consequently, those intermediaries, rather than the ultimate beneficiaries (farmers and consumers), are the users toward whom technology transfer efforts are mainly targeted. In turn, the intermediaries, with their own unique technical and marketing capabilities and resources, build upon the new scientific framework and develop new products, processes, or practices that meet the needs of farmers and consumers. Examples are more specific and safer pest-management systems based upon new knowledge of insect reproductive behavior or metabolism; grading and quality control of agricultural commodities and processed products monitored by automated spectroscopic instruments; and improved livestock disease vaccines developed from molecular biological information and genetic engineering techniques.

4. Encourage and assist users in exploiting directly applicable ARS research results. This objective pertains to research findings that require little or no further elaboration for use in existing operations. Examples are analytical methods for regulatory agencies, data on germplasm characteristics for plant breeders, refinements in conservation systems for farmers, mathematical soil erosion models for conservationists, and sludge-composting techniques for municipal governments.

ARS TECHNOLOGY TRANSFER MECHANISMS

The objectives of the ARS Technology Transfer Plan are achieved by coordinated combinations of eight mechanisms.

1. Direct communication between scientists and users. ARS researchers communicate their results to targeted groups of users and potential users and assist them in applying research findings to solve food and agricultural problems through the following technology transfer activities:

- Explaining their research findings at special exhibits, field days, open houses for farmers and ranchers, and to industry, commodity organizations, consumers, and other key users.
- Serving as technical advisers.
- Participating in formal meetings (such as that between lipid researchers of the Northern Regional Research Center and the Institute of Shortening and Edible Oils Technical Committee).
- Writing trade press articles.
- Individual contacts with user group representatives.

Modern electronic and automated communication systems will be used, where advantageous, to facilitate those activities. Some activities in this mechanism also provide major sources of feedback information from users to guide ARS program planning and evaluation.

Once ARS decides to use one or more of the scientist-to-user communication activities for transferring specific technology, research managers will lead and control the effort to ensure appropriate participation by involved scientists. In the evaluation and reward system through which the scientists' careers are advanced, procedures are available to give credit for such activities according to their effectiveness. Managers will evaluate activities and reward scientists.

2. Involvement of users and potential users in research planning and evaluation. Administrators of ARS have observed that the transfer of research results and adoption of new technology are most likely when users participate in planning and evaluating the research. They explain their observations by three reasons. First, potential users have intellectual investments in the research and, therefore, want to see it come to fruition through practical application. Second, the users' involvement in planning and evaluation helps to focus the research on their problems and helps to keep it on target. Third, users are aware of the research, follow its progress toward solving problems, and can prepare in advance to take advantage of it in an orderly fashion.

The second reason is especially important because feedback from participating users provides invaluable information to help ARS identify and assess problems and set priorities. ARS will invite potential users to participate at two levels in planning and evaluating its research. At the headquarters level, the National Program Staff will consider the input of responsible user representatives in its annual updating of the ARS 6-Year Implementation Plan. At the location or laboratory level, program review teams will continue to include scientists from other Government agencies, the academic community, and industry. This mechanism is used extensively with industry and with action and regulatory agencies. For example, the Universal Soil Loss Equation (USLE) was developed by ARS in consultation with the Soil Conservation Service (SCS) and others. The USLE is now in general use by SCS, the Environmental Protection Agency (EPA), and other organizations worldwide both for evaluating and predicting the effects of different soil and crop management practices on soil erosion caused by water.

3. Joint research with users and potential users. Often the advantages of mechanism 2 can be enhanced by going a step further and arranging for joint participation of the user in the research. For some projects, joint participation may be most appropriate at inception. For others it may be preferable at a stage where some overlap is needed as ARS is phasing out the research, which can be picked up by the user to develop new technology that is suitable for a particular operation. In any event, the joint research may function through formal sharing of information and experimental material as in the development of vaccines for foot-and-mouth disease and avian coccidiosis; scientist exchanges between ARS and industrial laboratories; or colocation of scientists, for example, ARS and APHIS at Plum Island, N.Y., and ARS and SCS at Temple, Tex. ARS managers will facilitate and support such joint research undertakings to achieve needed technology transfer without excessive diversion of resources from other high-priority research.

4. Transfer ARS research findings to Cooperative Extension Services by computer. The Cooperative Extension Services (CES) operated by the 1862 and 1890 Land-Grant Universities have long been major contacts for receiving and transferring ARS research findings to users. In late 1983 a new system was devised to transfer ARS research findings directly to CES by a nationwide computer network. In this system, the procedures for handling research findings (described in mechanism 8) are coordinated with the National Accomplishments Reporting System (NARS) of the Extension Service. Interpretive summaries of ARS research results that are suitable for transfer to Extension will be transmitted monthly from the ARS-Management Information System (ARS-MIS) database to the Extension NARS network. The new results are then immediately available for retrieval on computer terminals located in the 50 States. In addition, the system provides Extension personnel with information on patent status and the name, address, and phone number of a scientist to contact for additional information.

The "targeted" users of the ARS research results transferred to Extension are the specialists who assimilate and adapt findings for the use of farmers and other end-users in their States.

Later, this project will use the NARS and ARS-MIS nationwide computer networks to provide a flow of information on research needs from Extension to ARS. The communication of research findings and research needs by computer networks will augment long-term existing transfer mechanisms between ARS and Extension. The completed two-way system is expected to be in full service by Jan. 1, 1985.

5. Reporting research by ARS Information Staff. The Information Staff plays a key role in transferring technology to public and private users. Its efforts also reinforce the identity of ARS as the lead research agency in food and agriculture. Its coordinated program presents ARS achievements to both the general public and specialized audiences by preparing informational products for the Nation's print and electronic news media, by making systematic contacts with the working press and opinion leaders, and through production of a wide variety of technical publications, as well as periodicals, aimed at farm, commodity-oriented and other specific audiences. Agricultural Research magazine, for example, targets mailing lists to such audiences as the general news media, trade press, industry and trade associations, colleges and universities, sister agencies in USDA, and other units of government involved in both action and regulatory activities.

6. Patent activities. The ARS patent advisers prepare and pursue applications for patents on inventions and discoveries of the Agency scientists. Patent committees review and assign priority to requests from individual scientists to ensure that the most promising research accomplishments get preferential attention. The Agency has negotiated a Memorandum of Understanding (MOU) with the Department of Commerce' National Technical Information Service (NTIS) under which the NTIS may grant and administer an exclusive license to an agribusiness firm interested in commercializing a patented technology (or some specific component thereof) based on ARS research. Through that procedure, ARS research managers will encourage and support exclusive licensing, which increases the incentive for agribusiness firms to commercialize ARS technology.

7. Participation in the Federal Laboratory Consortium (FLC). The FLC is legislatively sanctioned as a technology transfer mechanism by Public Law 96-480 (the Stevenson-Wydler Technology Innovation Act of 1980), "particularly in dealing with State and local governments." An information network of Federal scientists serves as a communication channel between the Consortium and Government laboratories and potential users of research findings. The ARS is a supporting member of FLC, and the two technology transfer coordinators of ARS (see below under ARS Technology Transfer Coordination and Tracking) maintain liaison with the Consortium. Throughout the Nation, 15 ARS laboratories have been formally identified to FLC as major sources of technology pertinent to its mission. Research managers in charge of these laboratories will complement the roles of the two ARS technology transfer coordinators in promoting the involvement of ARS scientists in FLC activities.

8. System for electronically collecting, storing, and retrieving the latest research findings for technology transfer. Technology transfer begins with the research findings of ARS scientists. Manuscripts reporting the findings are reviewed by peers and approved for publication by area directors. A brief interpretive summary and an abstract are entered, along with other information, on a special form. The Area Director sends that form to the ARS Office of Research and Technology Applications (ORTA) immediately after approving the manuscripts for publication. Copies of the reporting form are also sent to regional ARS information offices to use in preparing news releases. This new, centralized system ensures that a steady flow of the latest scientific information is available for transfer by all appropriate means.

With the new system and its associated followup, the latest research findings can be transmitted to targeted groups of users and potential users. The groups include not only traditional ones--producers, commodity-oriented organizations, consumers, action and regulatory agencies--but also Small Business Development Centers, National Technical Information Service, Federal Laboratory Consortium, and State and local governments.

INTEGRATION OF TECHNOLOGY TRANSFER AND RESEARCH

Figure 1 illustrates both the integration of technology transfer into the management of ARS and the function of technology transfer among the processes through which the Administrator operates the Agency. Feedback from technology transfer provides important inputs to problem identification and assessment. Then follows long-range strategic planning to guide the Agency's research into the 21st century. Strategic planning provides the background for the second phase, implementation planning, that projects research programs over a 6-year period based upon realistically anticipated annual resources. In the third phase, operational planning, priorities are set and decisions are made about the commitment of scientists and facilities to specific aspects (subproblems) of broad national or regional problems. Resource allocation depends upon the priorities and decisions from operational planning. The amount and nature of research activity are influenced by the three planning phases as well as by resource allocation.

Before experiments are started, research activity begins with concepts and designs. After experiments are completed, research activity continues with the interpretation and evaluation of the data, and concludes with communication of the findings to the scientific sector of the public--usually by publication in specialized professional journals, Agency and Departmental publications, and presentations to scientific meetings. The more than 3,000 journal articles that ARS scientists write each year represent the traditional channel for disseminating research findings. In ARS, however, those articles are considered an essential part of research activity--as distinguished from the activities included in the ARS Technology Transfer Plan. The interpretive summaries of journal articles are sent to ORTA and become the backbone of the new, centralized, electronic system for transfer to the public by a number of mechanisms.

LEVEL OF CURRENT ARS TECHNOLOGY TRANSFER EFFORTS

A recent survey (table 1) of 2,400 scientists (85 pct. of total) indicated that more than 61,000 contacts and 85 years of ARS scientists' time were devoted to measurable technology transfer efforts (table 2) in fiscal year (FY) 1983. The time expended represented 3.6 percent of the total 2,400 scientist-years.

Technology Transfer Activities by Scientists

Key users contacted were educational, action, and regulatory agencies; farmers and ranchers and their organizations; industries; commodity-oriented groups; State and local governments; consumers and consumer groups; and international groups. Among those groups (fig. 2) the effort and time spent in FY 1983 were greatest with industry (26.5 pct.), followed by action and regulatory agencies (17.2 pct.). Other key user groups accorded major segments of the total technology transfer effort by ARS scientists were State and local governments, Extension, and farmers and ranchers. Those key user groups received 88.1 percent of the total time ARS scientists devoted to technology transfer. Consumers and consumer groups received 5.6 percent of technology transfer time; the 12,536 contacts with them were second only to the 12,988 contacts with industry (table 1, fig. 2).

Activities were mainly individual contacts, joint research arrangements, and formal meetings with groups. Those three activities accounted for 26.6, 19.5, and 15.6 percent of scientist-years, respectively (table 2) and--along with service as technical advisers to groups--accounted for more than 75 percent of the total scientist-years used for technology transfer.

The survey provides an estimate of technology transfer efforts by ARS scientists for a "typical" year. The total scientific time spent on technology transfer is between 3 and 4 percent, and the number of contacts with a wide spectrum of potential users of ARS research findings is substantial. A later section cites examples of the successful transfer of ARS-developed technology to key users through efforts initiated by ARS scientists.

Other ARS Actions to Transfer Technology

In addition to the contacts and actions by ARS scientists with key users documented above, approximately 80 years of effort to assist transfer of technology were expended in FY 1983 by other groups in ARS. These included the ARS Information Staff (66 staff-years) and patent assistance at regional and national levels (12 staff-years). Because technology transfer is inherent in the function of the National Program Staff, its contribution to the effort could not be estimated in staff-years.

Over the past 5 years, the ARS Patent License Office has processed 215 patents resulting from ARS research. That office maintains close liaison with the National Technical Information Service (NTIS), which has responsibility for licensing the patents granted on research conducted by Federal Agencies. ARS has, in recent years, transferred custody of 48 patents to NTIS for licensing. In 1983, NTIS issued three exclusive licenses to industrial firms for ARS-held patents; exclusive licenses were requested on 20 other ARS-held patents; one royalty bearing, nonexclusive license, based on an ARS-held patent, was granted; 13 nonexclusive licenses on ARS-held patents were issued; and ARS applied for 36 new patents.

EXAMPLES OF TECHNOLOGY TRANSFER BY ARS PROGRAM PLAN OBJECTIVES

In the ARS Program Plan, scientists identified the following six objectives:

Develop the means for--

1. Managing and conserving the Nation's soil and water resources for a stable and productive agriculture;

2. Maintaining and increasing the productivity and quality of crop plants;

3. Increasing the productivity of animals and the quality of animal products;

4. Achieving maximum use of agricultural products for domestic markets and export;

5. Promoting optimum human health and well-being through improved nutrition and family resource management; and

6. Integrating scientific knowledge of agricultural production, processing, and marketing into systems that optimize resource management and facilitate transfer of technology to users.

In pursuit of those objectives, the ARS Administrator directs managers and scientists in a common effort to improve the efficiency and effectiveness of research programs. In that effort, he emphasizes the adjustment of ARS programs so that the technology generated meets the needs and solves the problems of U.S. agriculture.

A few examples of important ARS research technology that was transferred to users between 1976 and 1983 are listed in table 3. Those examples illustrate the wide scope of ARS research and the diversity of the clients who assimilate and use ARS technology. The total potential return on the public investment in ARS research is conservatively estimated in billions of dollars per year. The combined return from just three of the technologies identified--irrigation scheduling, Marek's disease vaccine for poultry, and chemical growth regulators for fruit trees--is estimated at $263 million per year. ARS generated data for new grading standards for beef feeder cattle that could save $200 million per year. The potential benefit for lowering the costs of swine production through the use of genetic technology could be $366 million per year. The estimated annual benefits from full exploitation of only those sample technologies would total more than $800 million. Furthermore, the accrual of monetary returns continues as long as the application of the ARS technology remains profitable.

ARS TECHNOLOGY TRANSFER COORDINATION AND TRACKING

In ARS, technology transfer efforts will be planned, formally structured, coordinated, and tracked. Effectiveness and efficiency will be enhanced by increased use of modern electronic communication and automation systems. Research managers will be responsible for aiming and targeting technology transfer activities, for maintaining balance among the mechanisms of transfer, and for guiding appropriate interaction with technology users to achieve the objectives of technology transfer. With balance among the mechanisms of transfer and appropriate interactions with technology users, transfer activities will not unduly disrupt research programs. Managers will also be responsible for precautions against actual or apparent favoritism or conflict of interest in the transfer of technology to the private sector.

To ensure maximum ARS and public benefit, the probable contribution of technology transfer activities to the objectives will be considered in setting priorities among transfer efforts. Coordination of the activities will ensure that different sets of research findings that bear on a particular problem are delivered to users as a "package" of technology. The ARS research leaders and managers will include allocations for technology transfer in their annual plans.

To assist research managers and ensure nationwide coordination and tracking of technology transfer activities, ARS is establishing, in the National Program Staff at Beltsville, Md., an Office of Research and Technology Applications headed by a National Technology Transfer Coordinator. Among other duties, this official will coordinate technology transfer efforts throughout ARS, under the guidance of the National Program Staff. To complement the coordinator's work, a research manager at the Northern Regional Research Center, Peoria, Ill., will spend half his time coordinating technology transfer specifically for ARS Program Plan Objective 4 (Commodity Conversion and Delivery). The two coordinators will also record the type and evaluate the intensity of agencywide technology transfer efforts and monitor the relative success of the efforts. Such information will be valuable to the ARS Administrator and managers for increasing the effectiveness and efficiency of the technology transfer program. It will also serve as a data base for reporting ARS activities under the Stevenson-Wydler Act.

An additional responsibility of the technology transfer coordinators will be their work with research managers in developing guidelines for ensuring that specific research findings from different scientific disciplines and different locations are adopted to solve major problems related to feed, food, and fiber and their manufactured products. The coordinators should have at least two such projects under way at all times--possibly one apiece or two jointly. An example of such a technology transfer project could be a concerted effort with a wide range of new computerized near-infrared (NIR) spectroscopy techniques for the automatic quality control and grading of agricultural commodities ranging from forages through meats.

CONCLUSION

During the 30 years since ARS was established, the character of U.S. agriculture has changed markedly due to scientific advances. To continue providing needed research results ARS has planned strategically, and its Administrator is guiding research activities by the long-range ARS Program Plan and the updated 6-Year Implementation Plan. But plans, ideas, and discoveries do not save soil, increase either crop yields or pig litters, bring forth better or new products, make foods more nutritious, or manage farms more efficiently. To assure that these benefits are realized, ARS is organizing its activities for passing ideas and discoveries to the public in a better way through the ARS Technology Transfer Plan.

Figure 1

ARS Program Planning, Research Activity, and Technology Transfer

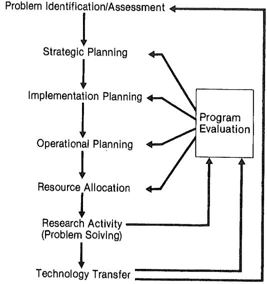

Figure 2

ARS Technology Transfer Percentage of Effort With Key Users Groups-Estimated FY 83

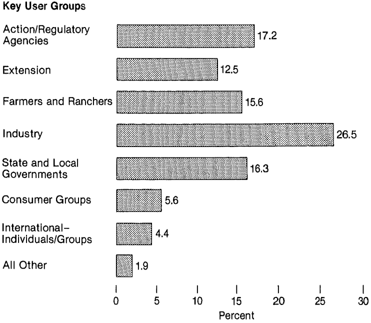

Table 1.-- ARS technology transfer contacts and scientist-years with key users, summary-FY 1983 (estimated[1])

Key users		Contacts	Scientist-years
		Number	Number
Action and regulatory agencies		7,435	14.6
Extension		7,671	10.6
Farmers and ranchers		11,555	13.3
Industry		12,988	22.6
State and local governments		6,147	13.9
Consumer groups		12,536	4.8
International - individuals/groups		1,923	3.7
Others		952	1.7
	Total	61,207	85.2

Total No. of scientists reporting - 2,400

Percentage of scientist-years technology transfer - 3.6%

---

[1] By scientists and or research leaders November/December 1983.

Table 2.-- ARS technology transfer, scientist-years by type of effort

Type of effort	Scientist-years	Percent
	No.	
Serve as technical adviser to groups	11.8	13.9
Hold formal meetings with groups	13.3	15.6
Write articles for trade press	6.3	7.4
Individual contacts	22.7	26.6
Joint research arrangements	16.6	19.5
Public press and other media	6.4	7.5
Demonstrations, field days, other "show and tell"	7.5	8.8
Other	0.6	0.7
Total	85.2	100.0

Table 3.--ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983

Objective 1 - Conserving Soil and Water

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Composting of sewage sludge, a process for safely treating municipal solid wastes for land applications.	Environmental Protection Agency. Economic Research Serv Consulting firms	Municipalities. Could be used for animal waste treatment. Being used by 1 papermaking company.	Method adopted by 71 cities in the U.S. Estimated that over 17,000 municipalities and 300 large cities have sewage sludge disposal problems. Current methods of disposal in landfills, oceans, or incinerators are not environmentally safe and are often costly. The composting process developed by ARS is cost-effective and safe and also recycles nutrients back into the food chain via forage and feed grains.
Methods of diagnosing, controlling, and reclaiming saline seeps in the Northern Great Plains of the U.S. and Canada.	Soil Conservation Serv. Extension Service State Conservation Districts. Agricultural Stabilization and Conservation Service (cost sharing).	Farmers Soil Conservation Districts. State agencies	This research is applicable to approximately 2 million acres in the Northern Great Plains of the U.S. and Canada and could prevent losses of $120 million annually in farm income for that region, $12 million in Montana alone.
Irrigation scheduling. A computer model for real-time irrigation scheduling was developed and made available to Federal and State agencies and private consultants. It formed the basis for the Bureau of Reclamation's irrigation management services, University of Nebraska AGNET, and consultant's irrigation programs.	Bureau of Reclamation University of Nebraska	Bureau of Reclamation. Extension Service State agencies Private consultants	Irrigation of over 2 million acres of irrigated land is scheduled by private and public service groups. Benefits derived include reduced pumping and fertilizer costs and increased yields. The program is a major component of a combination irrigation scheduling-electrical load management model for automatic, computer control of multi-center pivot sprinkler systems. Direct benefits to irrigators are estimated to be about $50 million annually.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 1 - Conserving Soil and Water—Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Design criteria and models of corrugated plastic soil drain tubing.	Not applicable	Drain tubing manufacturers. Soil Conservation Service. Private consultants	Corrugated plastic drain tubing has replaced 95 percent or more of the more expensive ceramic clay tile used almost exclusively for 135 years before 1970. An estimated 6 billion feet of corrugated plastic drain tubing has been installed in the U.S. during the past 10 years resulting in savings to U.S. farmers of about $1.2 billion.

successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 2 - Crop Productivity

Technology	Primary transfer agents other than ARS	Key users	Impact, actual potential
Automatic sprayer control system.	Industry and producers and publication in Transactions of ASAE 18:439-443, 1975, and presentation to Weed Science Society of America Annual Meeting in Feb. 1973, Atlanta, Ga.	Farm equipment industry. Farmers Commercial pesticide applicators.	A Nebraska study (Successful Farming, April 1980) showed that only 25 percent of Nebraska farmers apply pesticides within ± 10 percent. The costs of misapplication are estimated to be $2 to $12 per acre for added chemicals alone. Nationwide, these costs could exceed a billion dollars per year. Automatic controls can decrease losses caused by improper calibration by 46 percent.
The Woodward Flail-Vac Seed Stripper—Developed late 1980, early 1981, made public Sept. 1981 Field Day at ARS Southern Plains Range Research Station.	Individuals among more than 500 Field Day participants recognized the value of the equipment and soon formed a group (The Agricultural Renewal Group) to manufacture and sell the new seed stripper. Over 25 units were manufactured and sold for the 1982 production season and an even larger number were sold or made during 1983	Seed producers Commercial harvesters. Seed companies	The greatest impact of the seed stripper has been a marked increase in availability of chaffyseeded grass species for revegetation leading to markedly improved land productivity. This is readily evident from the increased seed availability and significantly larger planting of improved grass seed in the Southern Plains.
Alternatives to Mirex for fire ant control. Two new products, Amdro and Pro-Drone, are now commercially available and Affirm and Logic,— should be commercially available in the spring of 1984.	Industry Animal and Plant Health Inspection Service (APHIS).	APHIS fire ant control programs. General public	Environmentally safe and effective methods for controlling fire ants.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 2 - Crop Productivity—Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual potential
Based upon experimental research with chemical growth regulators on fruit trees, fruit growers now routinely use chemical fruit thinners and other growth regulators to reduce alternate bearing, improve fruit quality, and improve life of fruit during cold storage and in marketing channels. State agricultural experiment stations have conducted similar research.	State and Federal extension agents.	Commercial and home fruit growers throughout the U.S.	The estimated saving from the use of chemical growth regulators in the U.S. is $45 million annually.
Hycrest CRESTED WHEATGRASS—Developed a hybrid between induced tetraploid Fairway (*Agropyron cristatum*) and Standard (*A. desertorum*) crested wheatgrass. The cultivar is significantly more vigorous and productive than either parental species on western range sites, particularly during the seedling establishment phase.	USDA Soil Conservation Service will produce and distribute.	Private and public owners of western rangelands.	The impact of the new cultivar will be increased productivity of livestock grazing lands, revegetation of disturbed areas, and special-use situations (along roadways, arid turf, etc.). It is estimated that the present stocking of sagebrush, pinion-juniper, and desert shrub is 14.3 million animal-unit months (AUM). This could be increased to 58.5 million AUM's with presently available plant materials. Results indicate that at least an additional 25% increase could be achieved with Hycrest at a value of $1.40 per AUM; this amounts to $20,370,000 annually.

Table 5.--ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983--Continued

Objective 2 - Crop Productivity--Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Improved equipment for soybean harvesting.	Industry and producers and publications in Transactions of ASAE, numerous technical and user presentations, and 8,000 copies of ARS-NC-7 publication, "Soybean Harvesting," distributed through the Extension Service.	Farm equipment manufacturers, soybean producers.	Development and assumed eventual manufacture of the air-jet header was estimated in the 1975 ARS report to provide a return of approximately $490 million by 1980 on an investment of $580,000. Although the specific air-jet header design was never commercially manufactured, the research results provided the farm equipment industry with the technology to develop improved soybean headers of their own design. The results have provided an estimated savings of 1 bushel per acre for the average soybean farmer using the improved harvesters.
Elimination of toxicity problems associated with tall fescue forage grass.	State experiment stations. Cooperative Extension personnel relayed the research findings to the public and industry.	Cattle producers	There are presently 30 million acres planted in tall fescue for grazing. The eventual conversion of these pastures to fungal-free forage has been conservatively estimated to result in an increase in beef cattle production of $200 million.

Table 3.--ARS developed technology
successfully transferred to key users,
selected examples, 1970-1983--Continued

Objective 3 - Animal Productivity

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Developed a vaccine against Marek's disease, a devastating cancer of chickens.	Biologics firms, universities, poultry industry.	Biologics firms and industry.	In the U.S. alone, benefits from the control of the disease are estimated to total $168 million annually. These benefits compare favorably with the total expenditure of $32 million from 1965 to 1974 on all avian tumor viruses research, prior to the discovery.
Demonstrated that bluetongue virus is transmitted by a biting gnat, which can be controlled.	Researchers, experiment stations, sheep and cattle industry.	Sheep and cattle industry.	Provides a means to reduce the occurrence of bluetongue by integrated pest management techniques to control the insect which transmits the disease.
Production of the essential noninfectious component of foot-and-mouth disease virus for first genetically engineered vaccine against foot-and-mouth diseases in animals.	Biologics industry	Biologics industry; eventually the livestock industry and regulatory agencies in animal health.	Provides for a noninfectious particle which protects against a devastating foreign animal disease estimated to cost the livestock industry in the U.S. several billion dollars if allowed to be unchecked.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 3 - Animal Productivity—Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Genetic evaluations of dairy bulls and cows. This research program results in a basis for comparing the genetic transmitting ability of dairy bulls used in artificial breeding and has a major impact on selection decisions made by dairy farmers throughout the country and the world.	ARS submits the information directly to owners of animals and also to Extension. Extension agents and the news media distribute the information to dairy farmers.	Dairy farmers, dairy cattle-breeders, artificial insemination organizations.	The increase in milk production per cow occurring each year because of improved genetics is worth about $115 million at the farm level.
Activity monitoring technology in dairy cattle for estrus detection was developed in ARS and is being utilized by industry to provide devices for use by dairy farmers. Failure to detect estrus is a serious cause of reproduction inefficiency in dairy cattle.	Industry firms producing electronic "pedometers" for dairy cows.	Industry and dairy farmers	Application of this technology has the potential to reduce the average calving interval in dairy cattle. A reduction of 15 days has been estimated to result in an annual savings of $135 million to the U.S. dairy industry alone.

Table 3.--ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983--Continued

Objective 3 - Animal Productivity--Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
The first comprehensive summary of central swine testing station programs in the U.S. showed great diversity and total lack of coordinated efforts. A USDA publication on evaluating and using swine station performance records promoted understanding and use of national swine testing programs.	Genetic technology transferred initially by State extension swine specialists, purebred swine record associations, university breeding researchers, national swine industry periodicals, National Swine Improvement Federation.	Purebred swine record associations central swine testing stations, State-supported and private industry testing organizations, individual seedstock and commerical swine producers.	The total potential impact from the transfer of genetic technology for swine is estimated at $366 million saved per year, with benefits accruing to U.S. swine producers and consumers.
ARS research data were used as the basis for establishing new grade standards for feeder cattle. Extensive studies with feeder cattle showed that the frame size and muscling score used in combination as a classification system for feeder cattle were better than other live animal characteristics for (1) obtaining greater uniformity in carcass weights and quality and yield grades at slaughter and (2) improved efficiencies in handling and feeding of cattle.	Agricultural Marketing Service, USDA, utilized the results of the ARS study as the basis for developing and implementing new standards for USDA grades of feeder cattle.	AMS, USDA; Marketing News Reporting Service, USDA; State feeder cattle associations, Cattle feeders.	Data provided by ARS have resulted in the orderly marketing of feeder cattle. Over $200 million annual savings could be realized by industrywide adoption of the system.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 4 - Commodity Conversion and Delivery

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Near-infrared reflectance technology has been developed for rapid evaluation of the oil, moisture, and protein content of grains and oilseeds. This technology makes a reflectance measurement on a ground sample of grain and translates the information into a prediction of composition.	Transfer of this technology involved the Illinois State Department of Agriculture because they initiated a contract with instrument manufacturers to have the first practical instruments constructed from our designs.	Federal Grain Inspection Service, USDA; Canadian Grain Commission, Canada; terminal elevators; wheat millers; grain-processing firms.	This technology has revolutionized the evaluation of grain quality. Four firms in the U.S. and two firms in Europe are marketing instruments using this technology.
A durable flame-retardant treatment for commercial application to 100% cotton knitted or woven fabric was developed. This new, simple treatment utilizes a phosphorus-containing compound, THPOH, which is chemically fixed with anhydrous ammonia. Cotton garments so finished are virtually flame resistant and have no significant loss in strength or change in the feel of the fabric. Flame resistance is durable through more than 50 launderings.	None.	Chemical companies and textile finishers, steel mills, chemical producers, Firefighters, astronauts.	Fabric finished by this process is used in uniforms for U.S. Steel, Alcoa, Dow Chemical, Reynolds Metals, PPG Industries, Inland Steel, and Exxon Chemical. The cities of New York and Los Angeles have adopted this finish for uniforms for their firefighters. NASA has selected the finished fabrics for use by the astronauts. In 1982, over 8 million yards of fabric were finished by this process.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970–1983—Continued

Objective 4 - Commodity Conversion and Delivery—Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
New technology for minimization of formaldehyde release from textiles finished for durable press has grown from research conducted by ARS. Studies showed that the inclusion of glycols in finishing treatments could give reduced levels of formaldehyde release without adversely affecting smoothness, wrinkle resistance, and other important fabric properties. Working through a memorandum of understanding with a major textile-finishing company, ARS researchers developed the improved method through plant-scale trials.	Publication of the results by ARS transmitted the technology to the entire textile-finishing industry.	Textile finishers, chemical producers.	It has recently been estimated that about 2.5 million bales of cotton are consumed in the easy-care fabric market. Formaldehyde release is a critical property and, if not maintained at a level satisfactory to industry, consumers, and regulators, could cause loss of this large cotton market.
Chemical peeling of vegetables by methods which produced solid rather than liquid wastes. The wastes so produced could be used as animal feed instead of being discharged to sewers.	ARS was the principal transfer agent, but since the process required hardware, equipment manufacturers were involved early on and played a significant intermediate role.	Potato-processing industry.	This process was responsible for the survival of the potato-processing industry in the Pacific Northwest.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 4 - Community Conversion and Delivery—Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Developed an automated system for handling live poultry from the production houses to the poultry-processing line. Compartmentalized metal cages; hydraulically controlled lifting, tilting, and clamping devices; and belt conveyors were combined into a system which reduced labor, bruising, and mortality during the live-handling stage of processing.	Four poultry-processing equipment manufacturers are producing systems based on this research. Their designs are based on information provided by ARS publications and by observation of a demonstration project set up at a cooperating processing plant.	Forty poultry processors have installed this system at a cost of up to $600,000 each.	Estimated return of investment in labor savings and reduced product downgrading and loss comes in less than 18 months, and the return to the processing industry amounts to approximately $12-$14 million per year. The result is lower costs to processors and lower prices for poultry meat to consumers.
Developed new technologies and modified existing domestic technologies for harvesting, handling, packing and export systems (e.g. fungicidal treatments, modified atmospheres and transit temperatures, loading systems) essential to the opening of new markets and improvement of existing markets for U.S. fresh fruits, vegetables and floral products.	Large exporters of fresh fruits and vegetables utilized the information with the cooperation of FAS to establish and expand European markets. ARS prepared an Export Handbook citing specific technologies for specific commodities. ARS established a laboratory in Rotterdam, Netherlands, to provide technical support to FAS, and to exporters and importers in order to deliver better products to foreign markets.	Exporters of U.S. agricultural commodities as well as FAS and APHIS.	Texas Grapefruit to Europe - developed into a market of $12 million annually. Celery market lost to Israel because of poor quality—regained with appropriate technologies with an annual value of about $1 million. Made introduction of U.S. lettuce to Denmark and Sweden possible, currently an annual market of about $4 million.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970–1983—Continued

Objective 5 - Human Nutrition

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
The sugar content of dry cereals and the nutrient and energy content of "fast foods" including hamburgers and fried chicken from various outlets was determined and made available for entry into the Human Nutrition Information Service (HNIS) databank.	HNIS.	Nutritionists, food industry, and consumers.	Allow for preparation of more accurate nutritional information and more nutritious diets. These could provide the basis for improved nutrition for large numbers of consumers.
ARS research proved that soybean concentrate used as a meat expander in ground beef does not inhibit absorption of iron by young men consuming the product.	Food Safety and Inspection Services (FSIS), Department of Defense (DOD).	FSIS, DOD, food industry.	Lower cost diets for military personnel and consumers.
Manuals developed on breast feeding and lactation management (prenatal and post-partum) for mothers.	Women, Infants, and Children Program of the Food and Nutrition Service (FNS).	New mothers and mothers-to-be.	Improved nutrition and health of nursing infants and lower costs for families with new-born children.

Table 3.—ARS-developed technology
successfully transferred to key users,
selected examples, 1970-1983—Continued

Objective 6 - Integration of Systems

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
Remote sensing techniques, including methods for summarizing, screening, and evaluating data, for forecasting the yields of domestic and foreign crops.	Foreign Agricultural Service (FAS) and Statistical Reporting Service (SRS) personnel working directly with ARS scientists.	Same agencies plus the Central Intelligence Agency and World Agricultural Outlook Board.	The FAS makes production forecasts for 200 crop commodities in 100 foreign countries, and remote sensing plays a significant role in making these forecasts, especially in countries where ground-based observers cannot travel or where weather data are sparse. SRS has the same responsibility in the U.S. and now has acceptable forecasting methods, but they are costly. No one knows the value of this technology, but it is great. By one estimate, a 1-percent error in forecasting U.S. grain crops alone costs $300 million yearly.
EPIC (Erosion-Productivity Impact Calculator), a model for determining the relationships between erosion and the productivity of the Nation's soil resources, including economic and environmental impacts. Recently made available to Soil Conservation Service (SCS) and Economic Research Service (ERS) for the 1985 Resource Conservation Act assessment.	SCS and ERS personnel working directly with ARS scientists.	SCS, ERS, researchers, policymakers, Extension.	This model will provide the most precise and cost-effective evaluation of the costs of soil erosion ever available. It can simulate erosion effects over decades of time at a cost of 15 cents per year for each of the major soils in the U.S. This information will be invaluable for establishing rational conservation policies and programs for conserving soil productivity for future generations.

Table 5. ARS developed technology
successfully transferred to key users,
selected examples, 1970-1983--Continued

Objective 6 - Integration of Systems--Continued

Technology	Primary transfer agents other than ARS	Key users	Impact, actual/potential
CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems), a field scale model for evaluating the effects of different farming practices on nonpoint sources of water pollution.	Soil Conservation Service (SCS) personnel, especially the Regional Technical Centers.	SCS, Environmental Protection Agency, and other agencies interested in water quality.	This model can be used to evaluate the effects of past or current practices and to predict the effects of changing those practices on water runoff, sediments in water, and the plant nutrients or pesticides absorbed in the sediments or dissolved in the water. The model is a critical tool for protecting the quality of the Nation's water supplies.